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INTRODUCTION

This is the third progress report submitted on the research and development Task IV. The report covers the preliminary work done on the second pulse modulation system to be investigated, pulse time modulation.

DISCUSSION

The first method of pulse modulation that had been investigated was pulse amplitude modulation. This system was detailed and summarized in Progress Reports No. 1 and No. 2. The most serious disadvantage of the system was lack of security, inasmuch as any conventional A.M. Receiver tuned to the proper frequency could receive and demodulate the signal. Other significant disadvantages of P.A.M. were poor signal-to-noise ratio, and relatively poor transmitter efficiency.

The second pulse modulation system investigated was pulse time modulation, or pulse position modulation which in a modified form is pulse phase modulation. This method of modulation involves a pulse of constant amplitude, wherein the audio modulating signal causes to vary the position in time of the pulse relative to its unmodulated time of occurrence. Pulse time modulation has the usual advantages of pulse systems as compared to conventional A.M. and F.M. transmitters, namely, high peak R. F. power and small average R.F. power. This, in turn, offers the advantage of extended range or, if range is not a serious factor, the adaptability to miniaturization of the transmitter. The equipment designed for this specific application utilizes a pulse repetition rate of 8,000 cycles per second which is a cycle interval of 125 microseconds, and a pulse width of 10 microseconds. This represents a duty cycle of 12.5. However, the pulse width could be narrowed with a corresponding improvement of duty cycle and ratio of peak to average R. F. power.

A system utilizing a pulse of constant amplitude involves some inherent advantages. Firstly, any amplifier stage passing the pulse, either modulated or unmodulated, including R.F. modulated stages, need not be linear in design. The only requirement is an output pulse of constant amplitude, with no mis-shaping of pulse rise time or decay time. Likewise, the R.F. power output stage at the transmitter can be operated as a keyed or pulsed stage for maximum peak output.

Another very significant advantage of constant amplitude pulse systems pertains to signal-to-noise ratio. Normally, the noise accompanying a pulse is found along the base line, and riding the flat top of the pulse. This logically suggests a method of removing the noise, leaving the pulse with a good signal-to-noise ratio. This is accomplished by amplifying the pulse and clipping, both the base and top. This leaves the original middle section as the new pulse with none of the original noise. Since the process can be repeated, it lends itself automatically to a system of relays and repeater stations, for extended range. The obvious limitation for this sequence would be the deterioration to a signal-to-noise ratio of one. In this event, it could no longer be improved. A less obvious limitation of signal-to-noise ratio involves the rise time of the pulse. If this rise time interval is of significant duration, the noise will ride the rise line and this too, cannot be improved.

The rise time of the pulse is of significance in other respects, as well. The bandwidth requirement of the video amplifiers is determined by the rise time. Thus, for a rise time of 0.5

microseconds, a bandwidth of 1 megacycle is required. In a similar manner, the R.F. stages require a bandwidth of two megacycles.

The significance of bandwidth is further indicated in a Fourier analysis of the pulse. For a pulse of 8,000 cycles per second repetition rate and 10 microseconds duration, it was found that there were components of significant amplitude, as far as the tenth harmonic of the pulse repetition frequency. Theoretically, a pulse of infinitesimally short duration has a flat frequency spectrum.

There are two types of sampling possible in a system using pulse position modulation. They are uniform sampling and natural sampling. In the case of uniform sampling the modulating wave is assumed to be instantaneously sampled at regular intervals, and the pulses are subsequently position-modulated. This can be readily accomplished by converting the sample to a corresponding pulse duration modulated sample. This in turn becomes a pulse position modulated sample. In the case of natural sampling we produce P.P.M. by making the displacement of successive pulses from their unmodulated positions proportional to the magnitudes of the modulating wave at the instants of sending the pulses. That is, the time of sampling coincides with what can be regarded as the time of appearance of the position-modulated pulse. The latter method of sampling is the one utilized in the equipment described in this report. However, a system utilizing uniform sampling will be investigated concurrently.

The question of security in communication is particulerly pertinent to a system of pulse position modulation. Inherently, P.P.M. does offer security, inasmuch as a conventional communication receiver will not convert the signal to intelligible audio. Nevertheless, if the maximum excursion of a pulse from its unmodulated time of occurrence is made moderately small, a delayed copy of the original signal with little distortion could be obtained by simply passing the P.P.M. signal through a low pass filter followed by an appropriate amplifier. A mathematical analysis of a pulse position modulated wave indicates various components representing phase modulation as well as amplitude modulation components. The proper choice of maximum pulse deviation will make the amplitude coefficients negligible. In multiplex systems the degree of deviation is specifically limited to a maximum of one-half the distance between the unmodulated pulse positions of adjacent channels, less a chosen guard band. For our purpose there is no such restriction, and the deviation or excursion can be made wide enough to accomplish security.

TESTING and EQUIPMENT

The following is a discussion of the equipment designed for the investigation of a pulse position modulated system: Figure 1 is a block diagram of a pulse position modulation transmitter. This consists of two chassis. The first unit, Figure 2, is the modulator chassis, containing a pulse generator operating at 8,000 cycles per second, a modulator section, and a wide band regenerative amplifier. This unit is still undergoing tests, and is not yet in its final form.

The second chassis in the transmitter, Figure 3, is the R.F. section. The first stage is a tuned plate tuned grid oscillator operating at 55 megacycles. This frequency was chosen because of the two megacycle bandwidth requirement for the R.F. sections. At this frequency the bandwidth requirement for the receiver can be readily attained. The oscillator is lightly coupled to a buffer amplifier, which in turn is connected to the R.F. power output stage. The input to the fourth section, or first video amplifier, is P.P.M. pulses from the modulator chassis. This is fed to the second video amplifier, which in turn feeds the modulator stage. This latter stage passes the pulse through a pulse transformer to the R.F. power output stage, acting as a gating or keying device.

Figure 4, is a schematic diagram of a five stage video amplifier terminating in a low impedance cathode follower output. The overall frequency response extends to five megacycles, and results in a minimum of distortion or mis-shaping of the pulse derived from the modulator chassis of the transmitter. This unit will be used as a coupling chassis between the R.F., and detector stages of the receiver and the demodulator chassis. These two units are not completed as yet.

CONCLUSIONS and FUTURE PLANS

A pulse position modulated system is being designed and tested. The entire transmitter has been completed and is undergoing tests. Parts of the receiver have been completed and tested.

An analytical evaluation of a pulse amplitude modulated system which has been investigated and the P.P.M. systems, indicates that the P.P.M. should have the advantage of security, transmitter efficiency, and a choice of greater transmitter range and/or miniaturization of equipment.

It is planned to complete the design of a wide band receiver and demodulator, and test the pulse position modulator on a system basis.

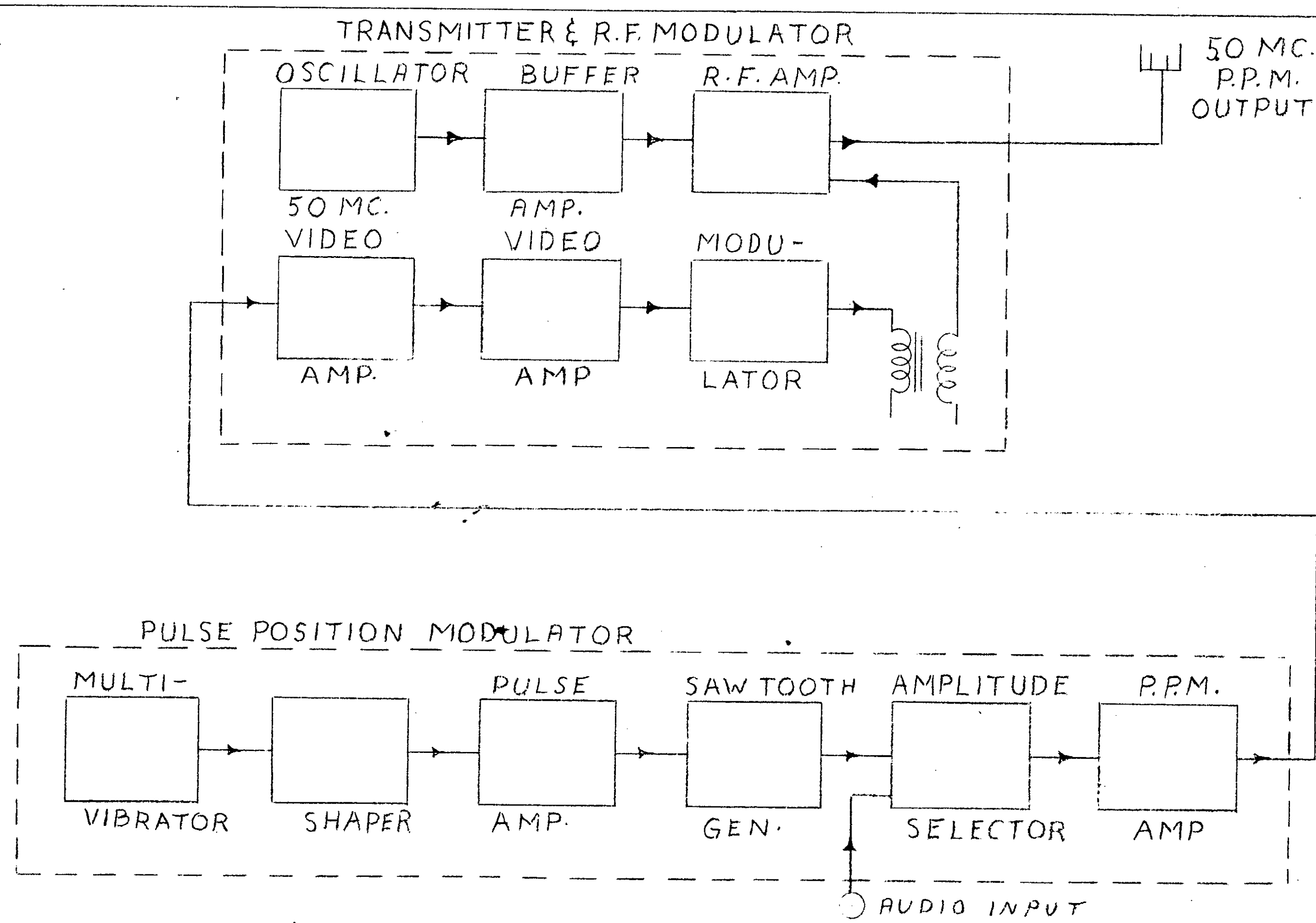
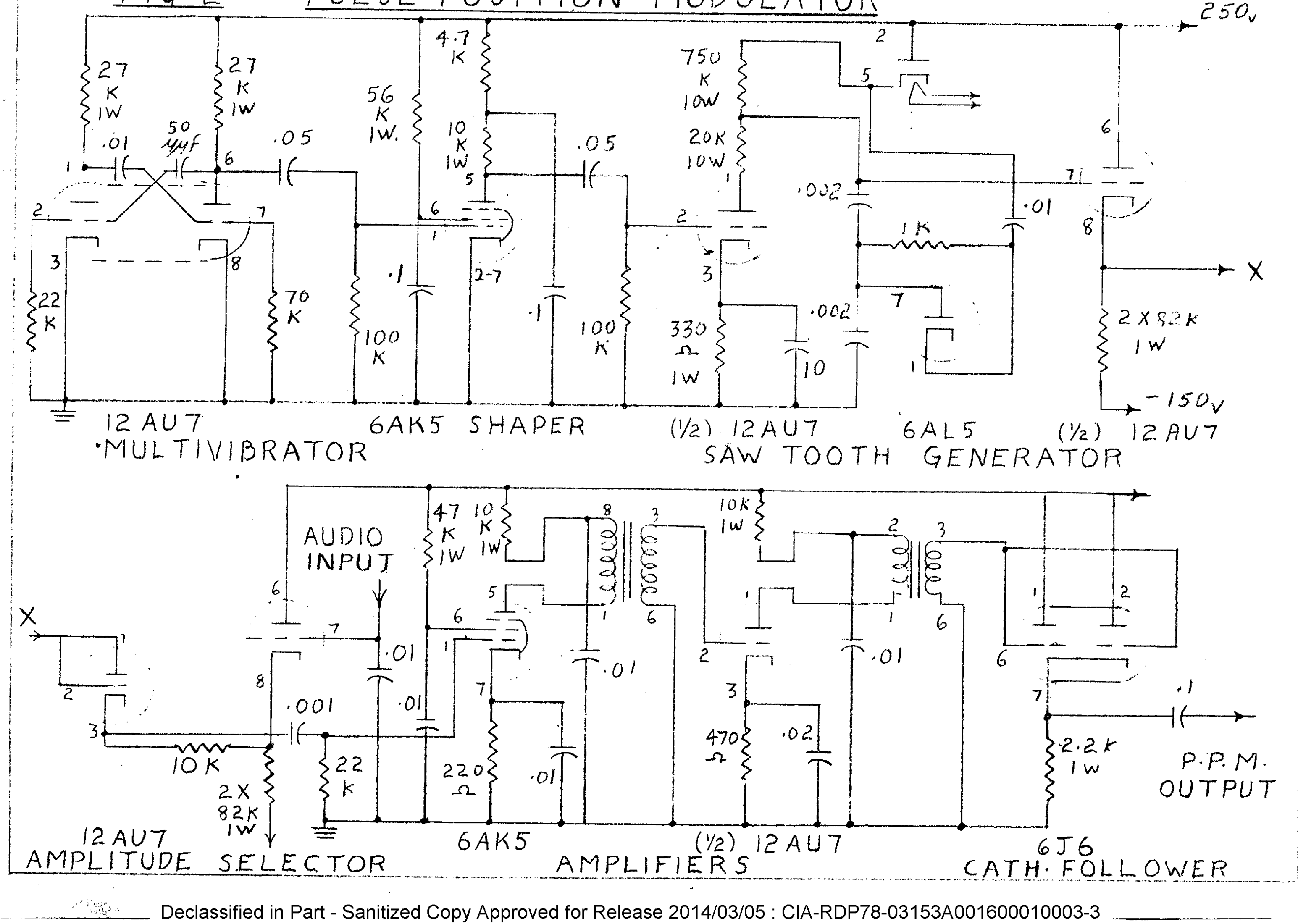


FIG. 1 - PULSE POSITION MODULATED TRANSMITTER

FIG. 2 PULSE POSITION MODULATOR



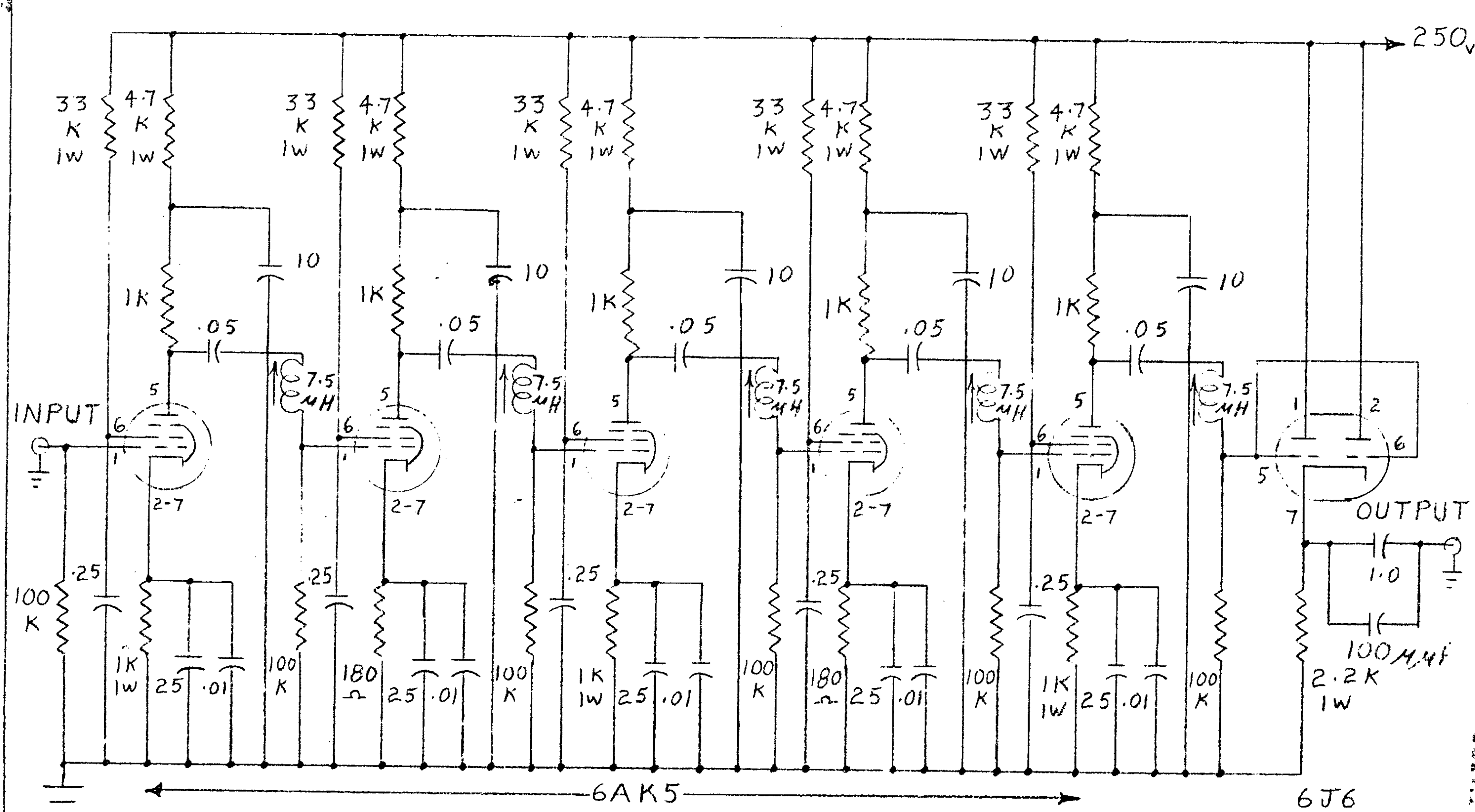


FIG. 4 VIDEO AMPLIFIER